Anderson Localization of Classical Waves In Disordered Photonic Crystals with Absorption or Gain

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Anderson localization of classical or electromagnetic waves In disordered media, although not unambiguously realized to date In 3D random media due to the ubiquitous presence of absorption, has recently regained Interest In becausee of Its possible relevance for random lasers [1]. We present a diagrammatic theory of Anderson localization of classical waves In 3D, disordered photonic crystals with absorption or gain. Since the standard mechanisms of Anderson localization, diffusion ("diffusons") and coherent backscattering ("Cooperons"), rely fundamentally on particle number conservation, which Is broken here, we reformulate the transort theory for absorbing/emitting media, employing an exact, generalized Ward Identity [2], and resum the modified diffuson and Cooperon contributions. We find that In absorbing media true Anderson localization Is Impossible. Stimulated emission, In turn, enhances the localization effect by Increasing the weight of long, constructively Interfering wave paths In the random system. The latter leads to a modification of the Ioffe-Regel criterion. We discuss, If this can explain the experimentally observed [1] localized modes In systems with gain whose mean free path by far exceeds the wave length of light.

[1] H. Cao et al., *Phys. Rev. Lett.* **82**, 2278 (1999); **84**, 5584 (2000).
[2] A. Lubatsch, J. Kroha, and K. Busch, *cond-mat/0412083* (2004).